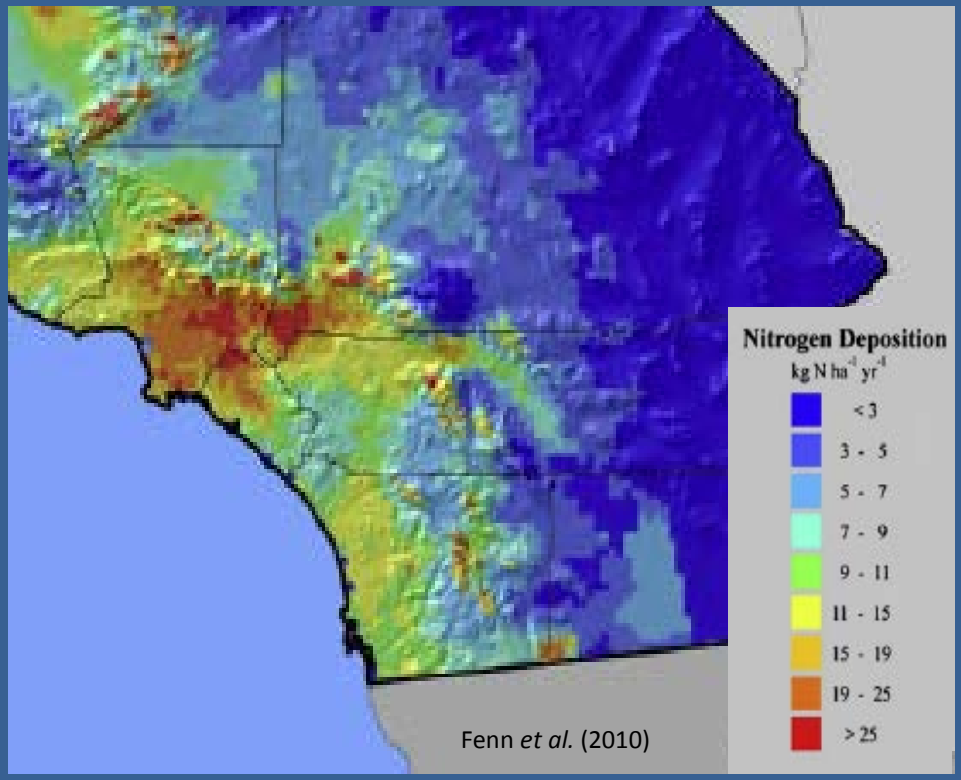
# Ecosystem flip-flops in response to anthropogenic N deposition: The importance of long-term experiments


George L Vourlitis, Biological Sciences Department, California State University San Marcos


California State University
SAN MARCOS

# Atmospheric N deposition

- Chaparral can receive up to 35 kgN $ha^{-1}$ $y^{-1}$ and coastal sage scrub (CSS) can receive up to 20 kgN $ha^{-1}$ $y^{-1}$; however, values can vary with elevation and degree of exposure.
- 90% is dry deposition.
- N accumulates in the summer and fall and becomes available as a large pulse following the first rainfall event.




- Chaparral and CSS productivity are thought to be N limited. N enrichment has the potential to alter chaparral and CSS C and N storage.

# Research objectives and approach

We used a long-term field experiment to assess how dry-season N inputs altered chaparral and CSS C and N storage and cycling.

We hypothesized that N addition would significantly

(1) increase rates of C and N accumulation.

(2) increase the cover and dominance of exotic annuals

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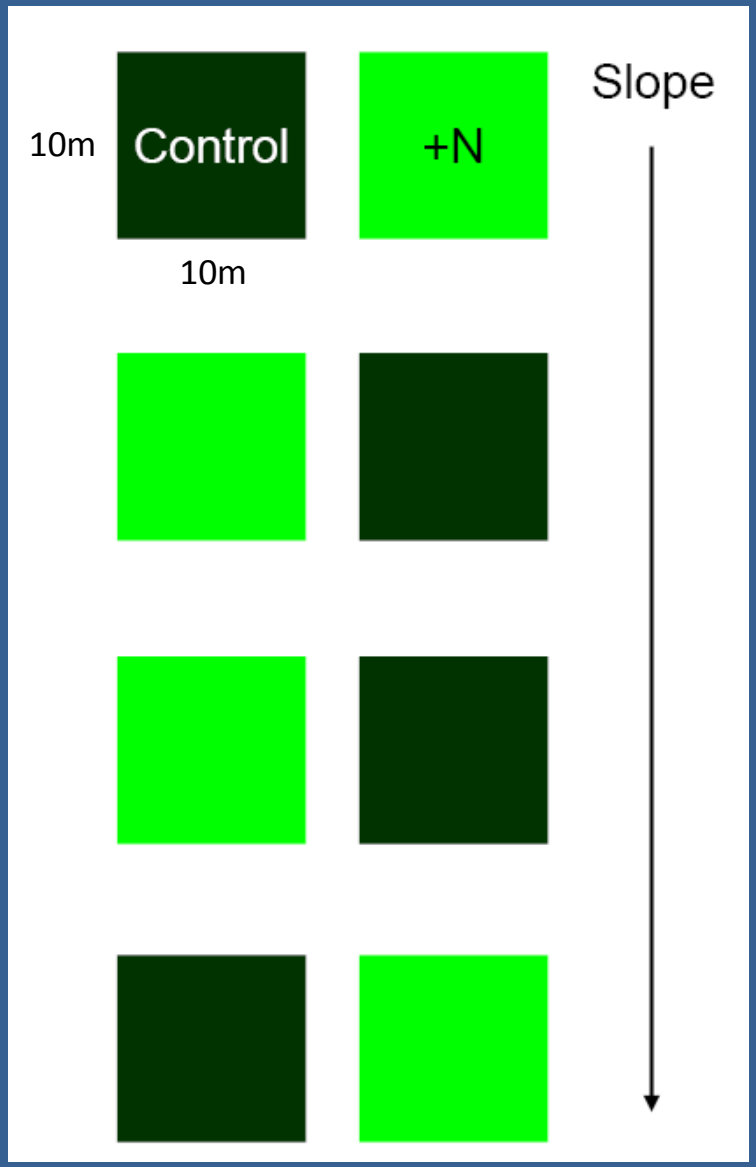
# Experimental design




- N-fertilizer (50 kgN/ha) is added in the fall of each year since September 2003.
- Samples were collected seasonally (March, June, September, and December).
- Soil (0-10 cm), surface litter pool, litter production, root biomass (0-10 cm), plant tissue, aboveground biomass and plant cover, leaching (1 m).
- C and N content of tissue, litter, soil, roots, extractable N, pH.

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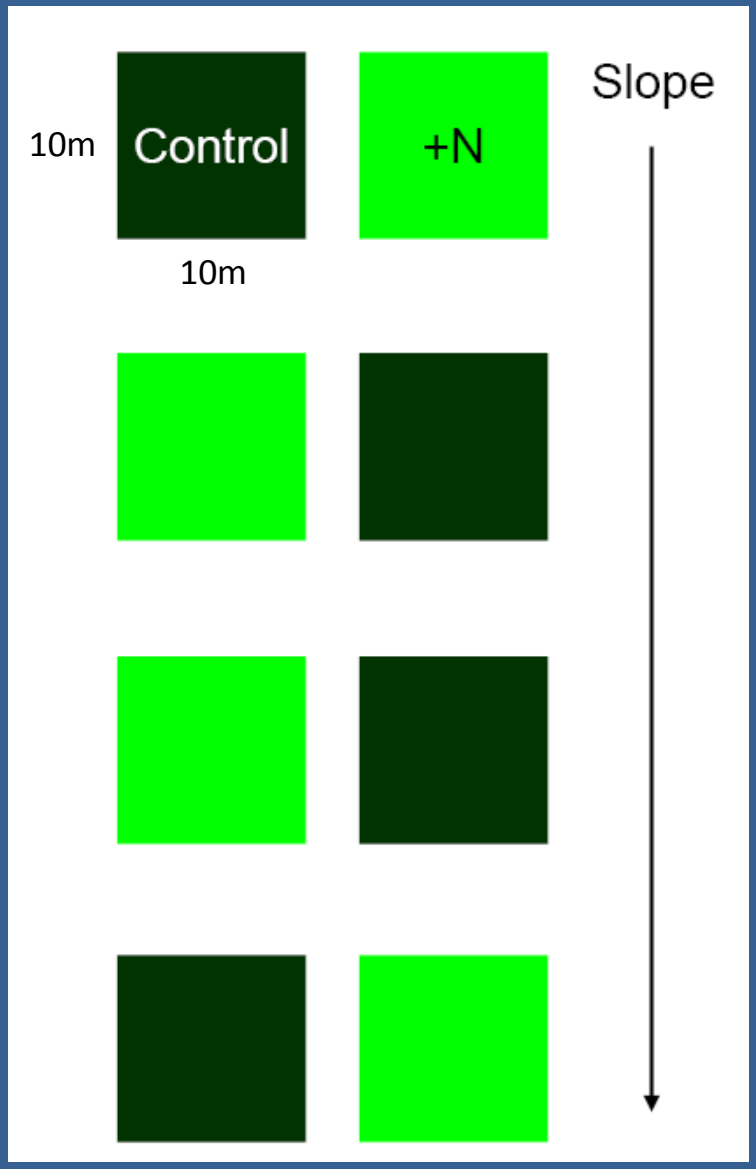


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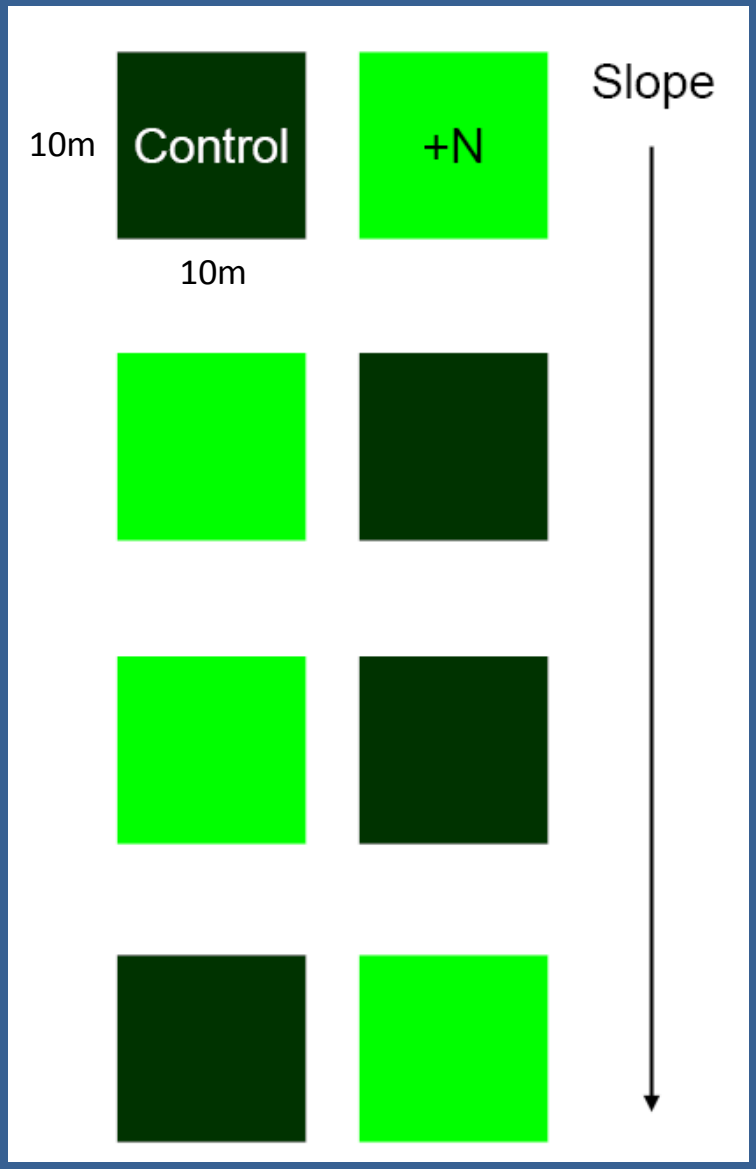


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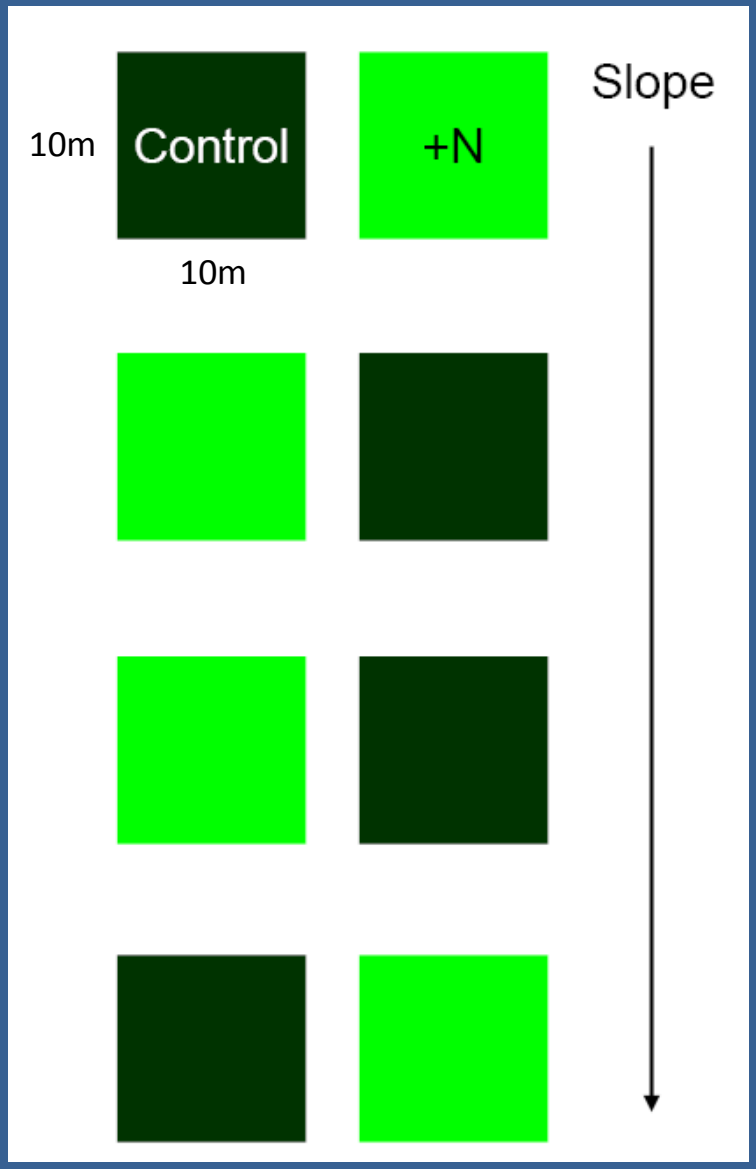


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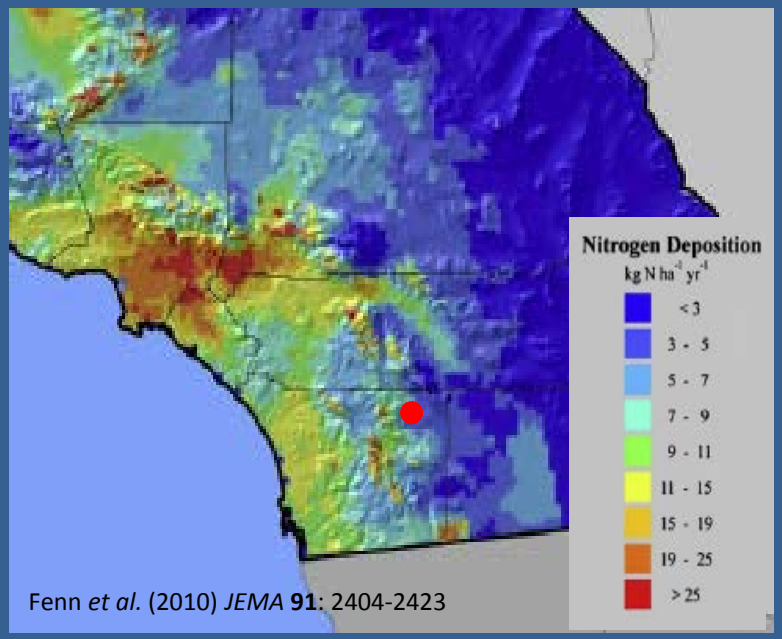
# Chaparral site description

Sky Oaks Field Station



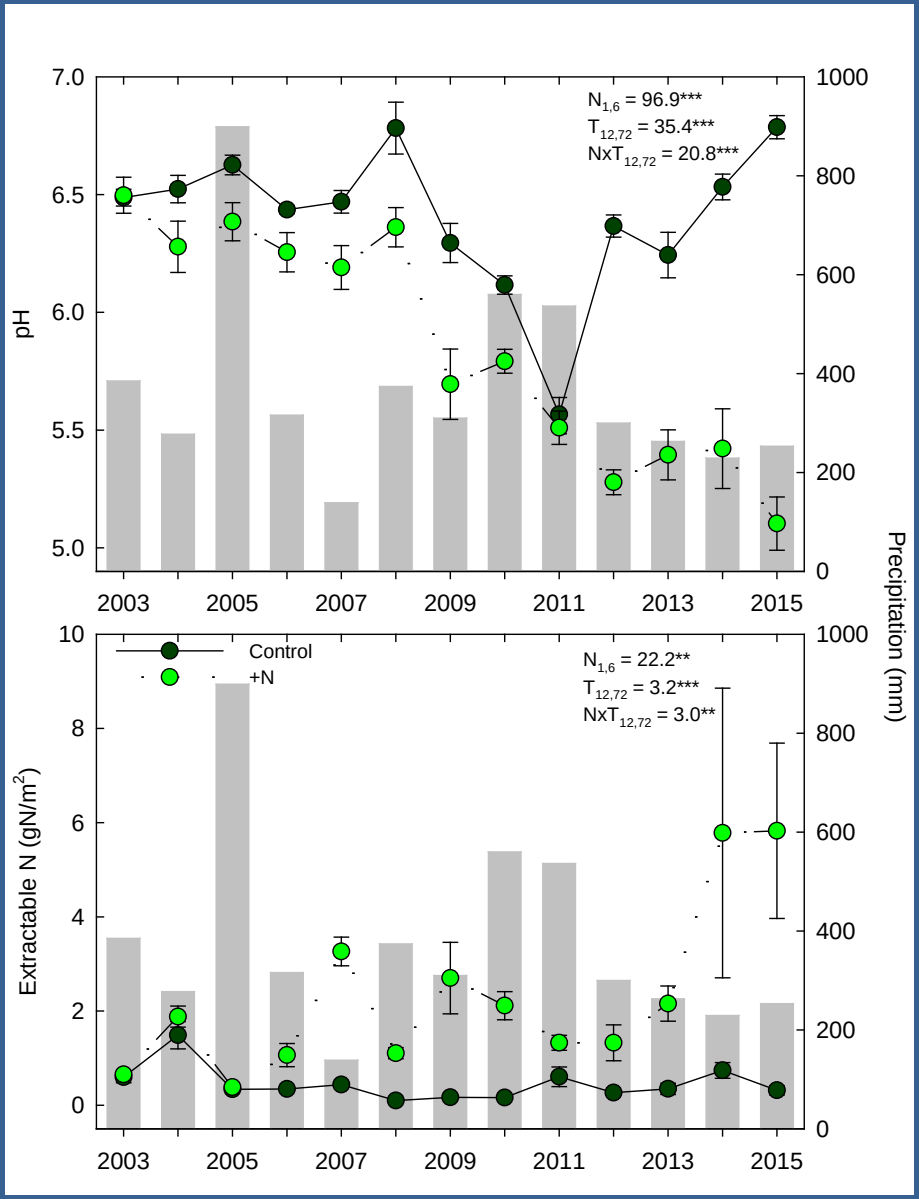

Fenn *et al.* (2010) *JEMA* **91**: 2404-2423

May 2002

March 2004

- Evergreen chaparral: *Adenostoma fasciculatum*, *Ceanothus greggii*.
- Ambient atmospheric N deposition 2-3 kgN $ha^{-1}$ $y^{-1}$.
- 53 cm of precipitation (rain and snow) annually.
- Burned in July 2003

# Chaparral extractable N and pH

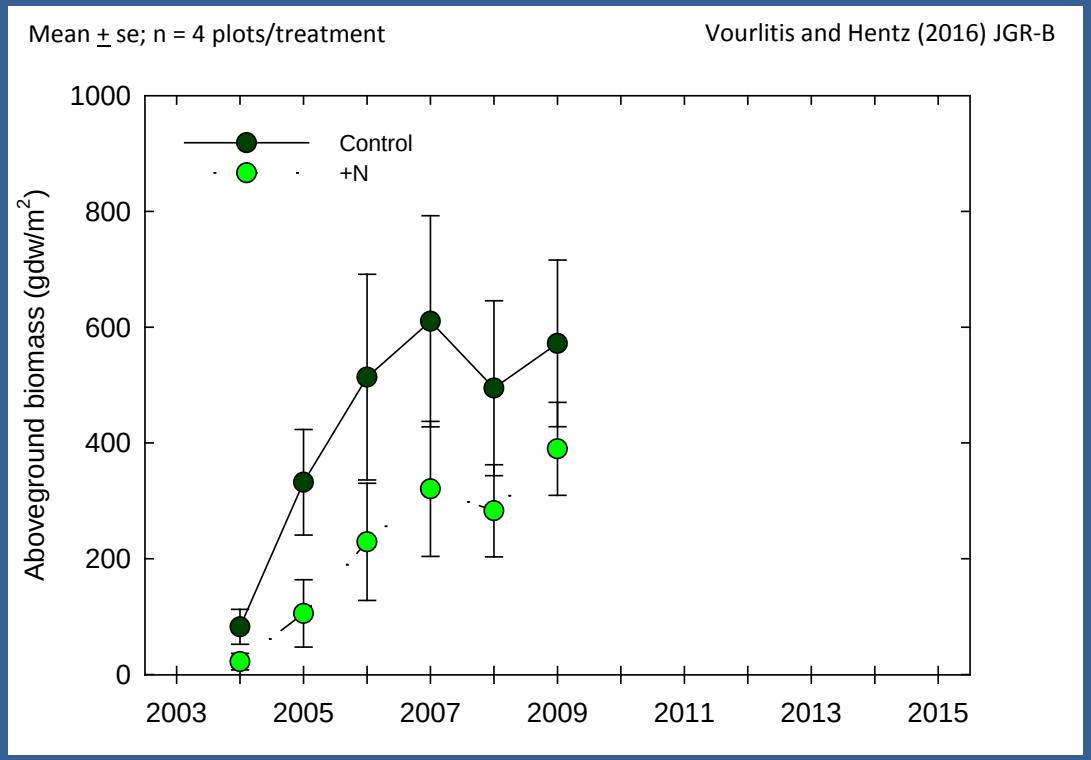



- Added N rapidly acidified surface (0-10 cm) soil
- Soil extractable soil N increased significantly after 1 year of addition.
- N addition significantly increased $NO_3^-$ leaching during the first 3 years of N addition (Vourlitis et al. 2009).

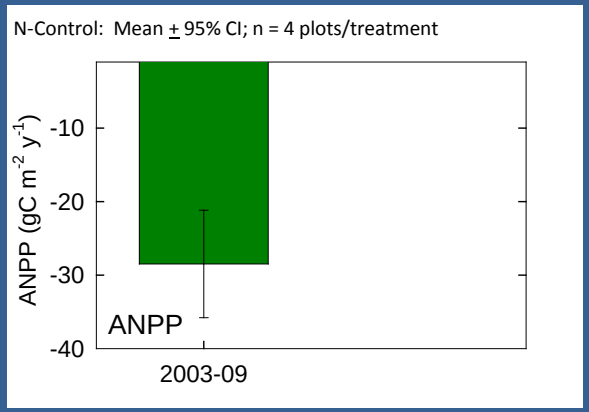
Mean ± se; n = 4 plots/treatment

Vourlitis and Hentz (2016) JGR-B

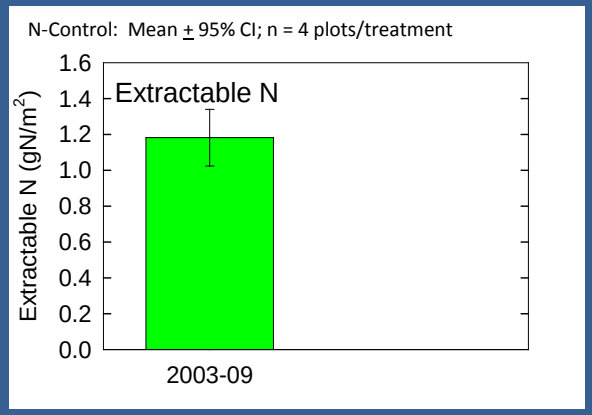
# Aboveground biomass production

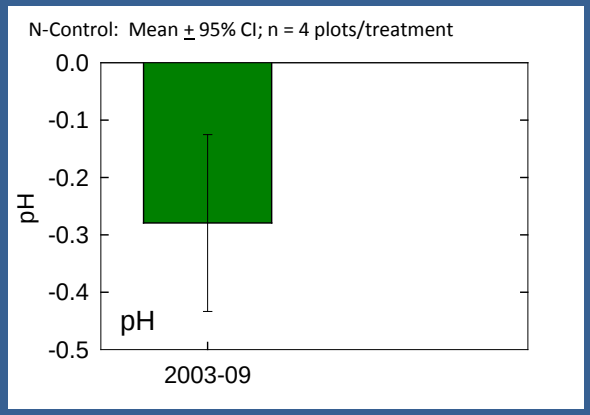



**During the first 6 years**, N plots had significantly lower aboveground biomass than control plots.



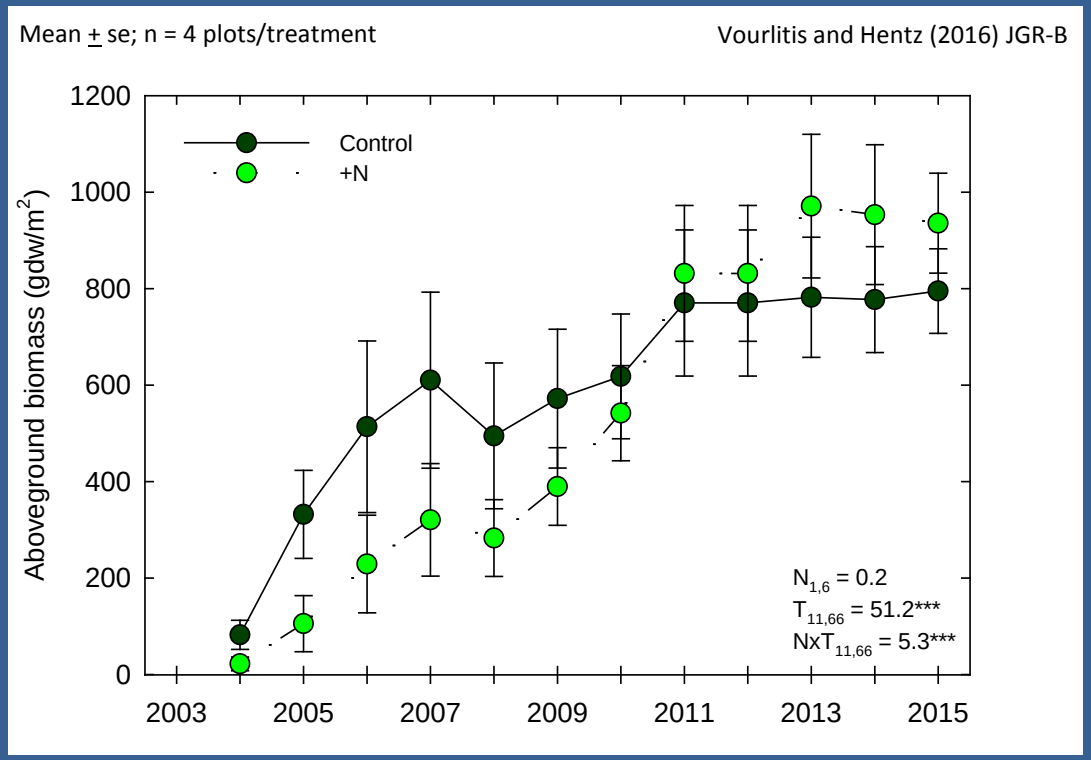

Resulting in significantly lower ANPP for N plots



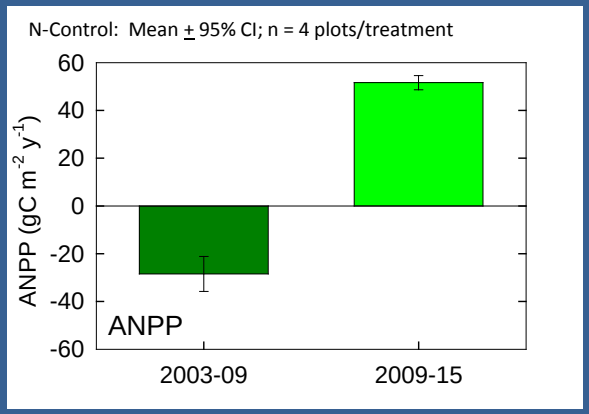




Dry season N addition significantly increased N availability and soil acidity

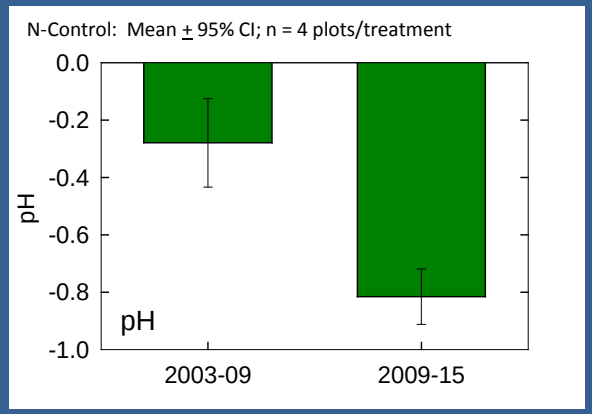
# Aboveground biomass increment

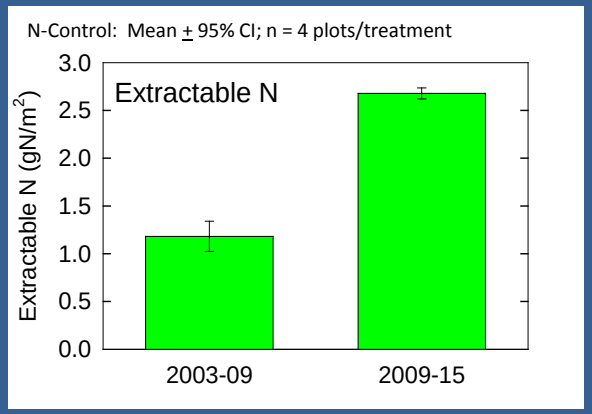



**During the last 6 years**, aboveground biomass of +N plots either equaled or exceeded control plots.



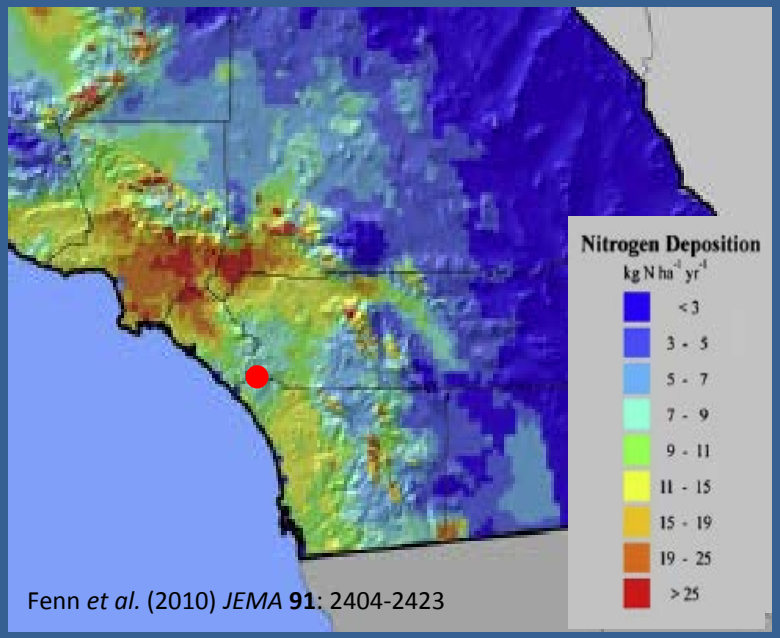

Resulting in significantly higher ANPP for N plots




Extractable N and soil acidification increased by > 2x in N plots

# CSS Site description




Fenn *et al.* (2010) *JEMA* **91**: 2404-2423

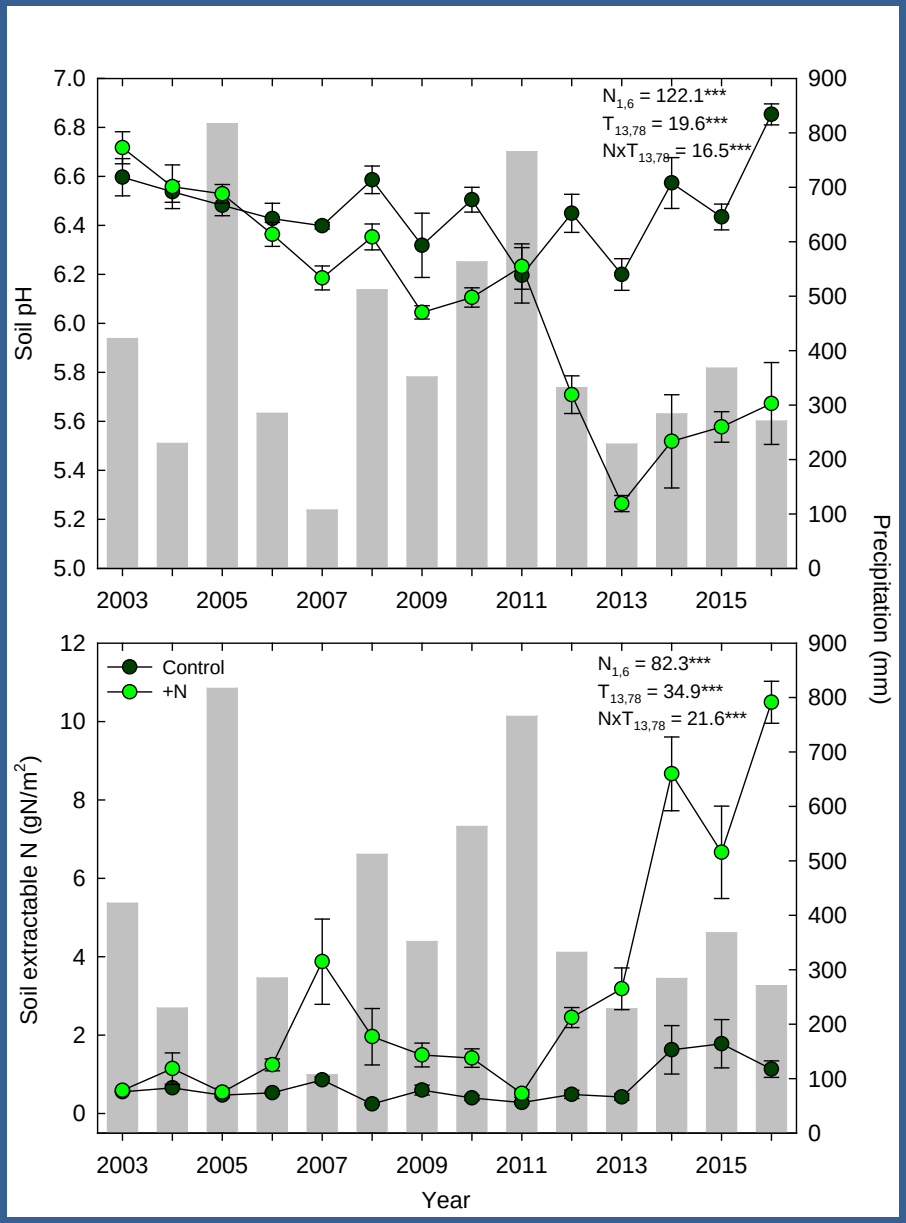
Dry season

Wet season

**Coastal sage scrub (CSS)**

- Santa Margarita Ecological Reserve
- *Artemisia californica*, *Salvia mellifera*.
- Ambient atmospheric N deposition 6-8 kgN $ha^{-1}$ $y^{-1}$.
- 36 cm of precipitation annually.
- Has not experienced fire for about 35-40 years.

# CSS extractable N and pH

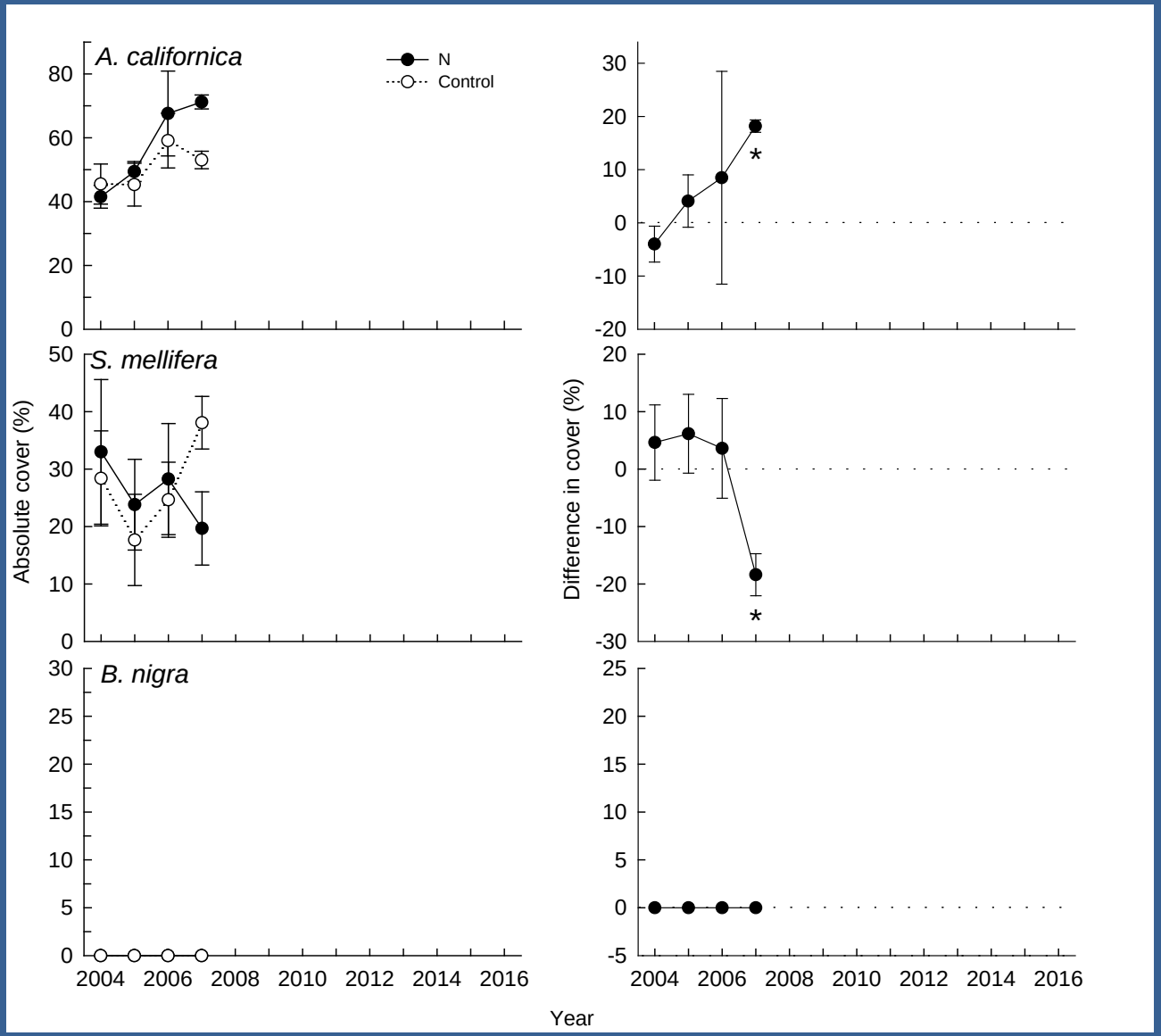



- Added N acidified surface (0-10 cm) soil after 4 years
- Soil extractable soil N increased significantly after 2 years of addition.

Mean ± se; n = 4 plots/treatment

Vourlitis (2017) Oecologia

# CSS cover and species composition

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Vourlitis (2017) Oecologia

After 4 years of N addition:

*Artemisia californica* increased significantly in N plots.

*Salvia mellifera* decreased significantly in N plots.

*Brassica nigra* cover was < 1 % in both control and N plots.

Drier period (except 2005).

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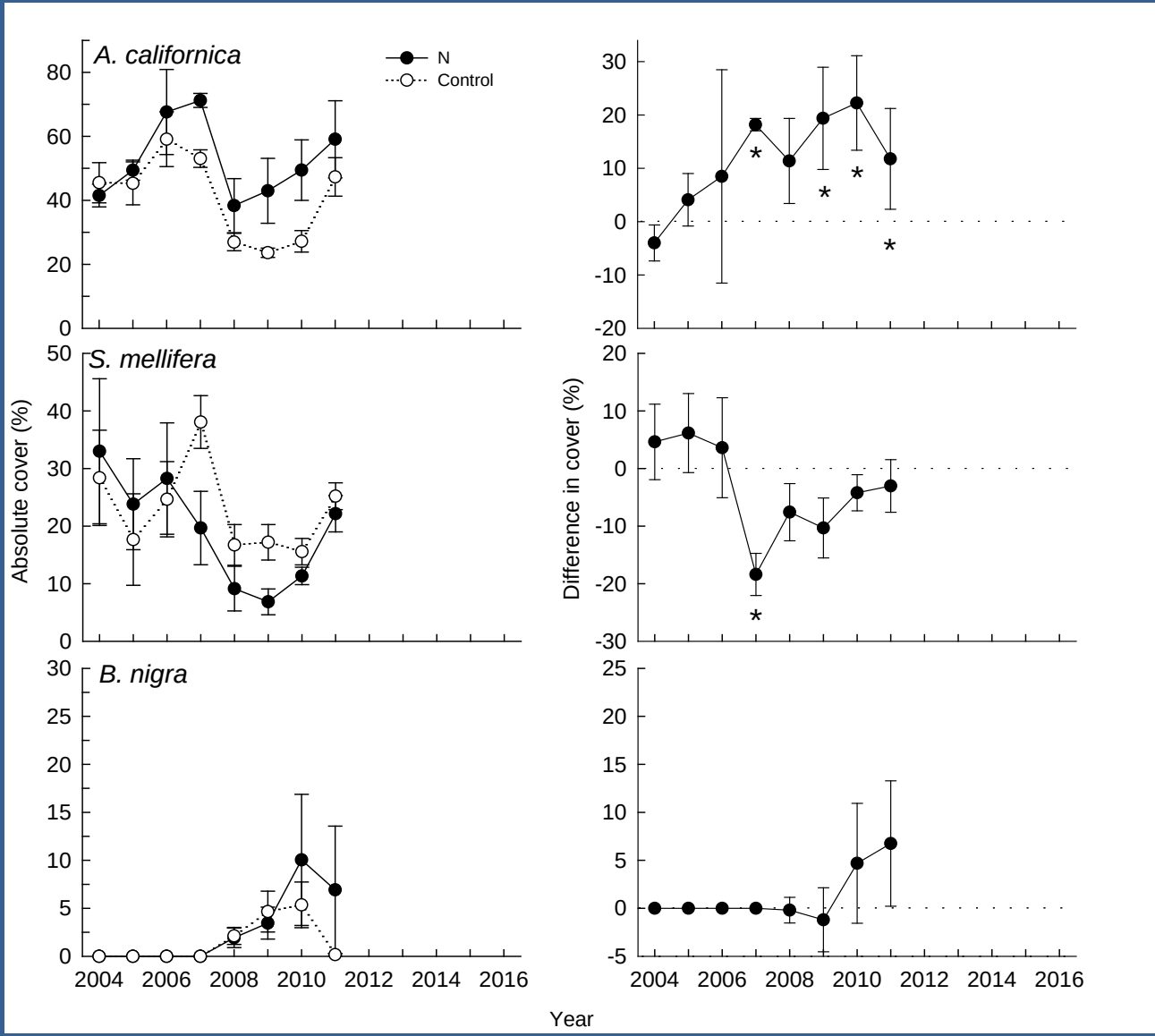


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Vourlitis (2017) Oecologia

After 8 years of N addition:

*Artemisia californica* cover begins to decline in N plots.

*Salvia mellifera* cover begins to increase in N plots.

*Brassica nigra* cover begins to increase in N plots.

Wetter period.

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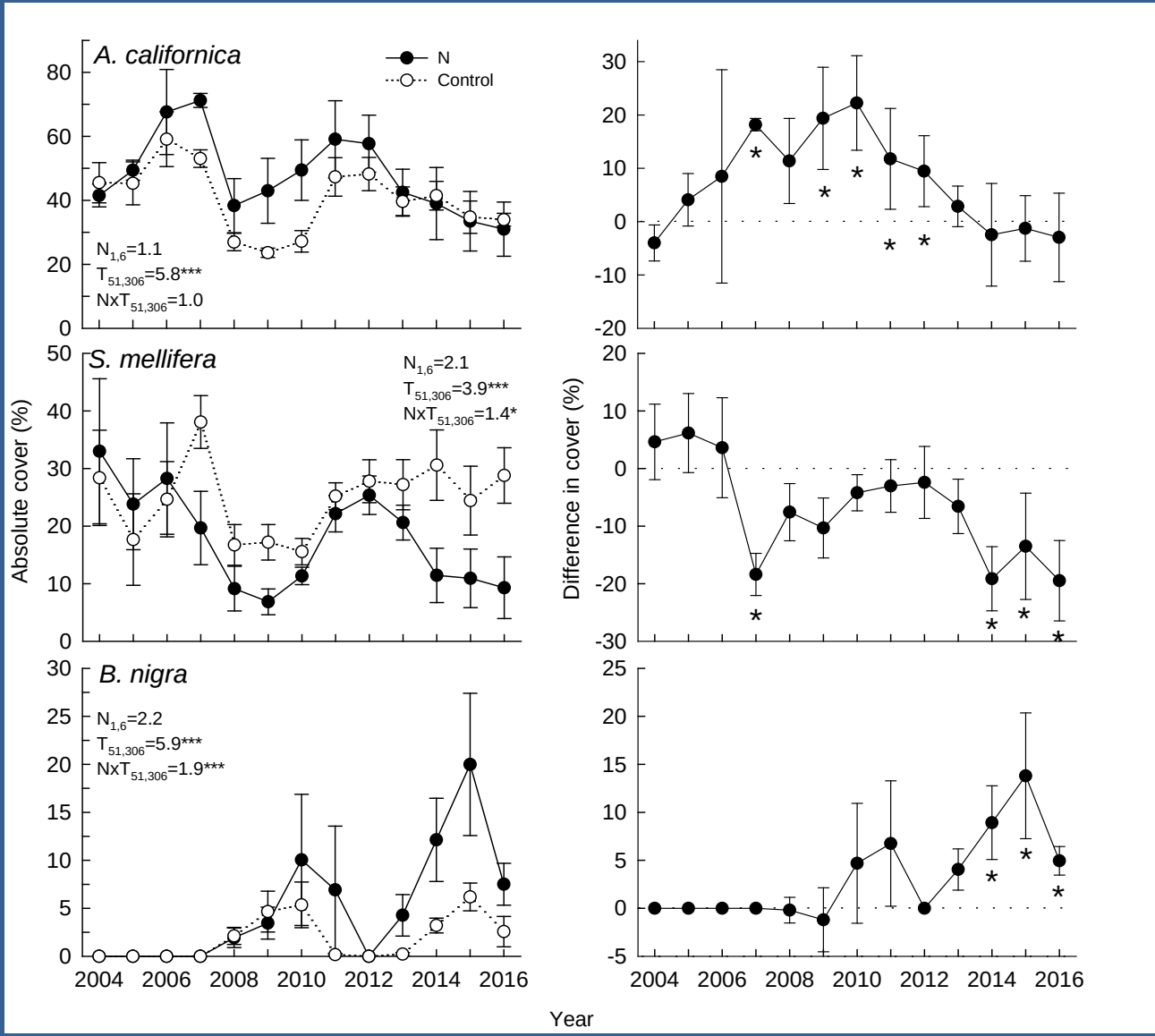


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Vourlitis (2017) Oecologia

After 13 years of N addition:

*Artemisia californica* cover is the same in N and control plots.

*Salvia mellifera* cover is significantly lower in N plots.

*Brassica nigra* cover is significantly higher in N plots.

Drier period.

# CSS cover and species composition

SMER: Plot 3 (Control)

Total cover = 55%

*B. nigra* cover = 20%

SMER: Plot 4 (+N)

Total cover = 66%

*B. nigra* cover = 52%

# Discussion/conclusions

We hypothesized that N addition would significantly

(1) increase rates of C and N accumulation.

Chaparral: Yes, but only after 7 years of N addition

CSS: Yes, but only when rainfall exceeded ca. 400 mm/y (Vourlitis 2012)

(2) Increase the cover and dominance of exotic annuals

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Chaparral: No, no change in species composition or richness after 14 years of N fertilization.

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These data indicate that ecosystem responses to N deposition are complex, may change over time, and interact with other environmental variables.

Long-term studies are needed to understand how N deposition will alter ecosystem structure and function.

CSUSM Terrestrial Ecosystems Research Lab

# Thank you!

California State University SAN MARCOS

USDA United States Department of Agriculture National Institute of Food and Agriculture

NSF National Science Foundation WHERE DISCOVERIES BEGIN

National Institutes of Health The Nation's Medical Research Agency

**Field Stations Program**
College of Arts and Sciences at San Diego State University